

## Membrane Shell Reflector Segment Antenna

**A tetrahedral truss provides rigidity and integrity for the reflector antenna.**

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The mesh reflector is the only type of large, in-space deployable antenna that has successfully flown in space. However, state-of-the-art large deployable mesh antenna systems are RF-frequency-limited by both global shape accuracy and local surface quality. The limitations of mesh reflectors stem from two factors. First, at higher frequencies, the porosity and surface roughness of the mesh results in loss and scattering of the signal. Second, the mesh material does not have any bending stiffness and thus cannot be formed into true parabolic (or other desired) shapes.

To advance the deployable reflector technology at high RF frequencies from the current state-of-the-art, significant improvements need to be made in three major aspects: a high-stability and high-precision deployable truss; a continuously curved RF reflecting surface (the function of the surface as well as its first derivative are both continuous); and the RF reflecting surface should be made of a continuous material. To meet these three requirements, the Membrane

Shell Reflector Segment (MSRS) antenna was developed.

A MSRS antenna is composed of a deployable tetrahedral truss that supports a set of MSRSs to form a high-definition, smooth, and continuous surface. This high radio-frequency (RF) deployable reflector is implemented by leveraging and integrating several recently developed material technologies: shape memory polymer (SMP) composite material; high-precision MSRS casting process; near-zero coefficient of thermal expansion (CTE) membrane material; and poly-vinylidene fluoride (PVDF) electro-active membrane. This reflector technology can potentially offer almost one order of magnitude higher precision than current state-of-the-art reflectors, and can provide very complex reflector shapes.

The structural part of this MSRS antenna is a tetrahedral truss that provides rigidity and integrity for the reflector. Tetrahedral trusses offer much higher precision than tensioning cable

trusses that are employed by all current state-of-the-art mesh reflectors. However, it is extremely difficult to package a tetrahedral truss by using traditional deployment mechanisms. The unique characteristic of the SMP composite makes it possible to package and deploy the whole reflector. The fundamental requirement on a high RF reflector, high precision, will naturally be met by the intrinsic accuracy characteristic of the tetrahedral configuration. The high-definition RF reflective surface is composed of a number of MSRSs made of either near-zero CTE Novastrat or PVDF membrane. The thickness and curvature of each MSRS provide sufficient shell stiffness for it to be supported by the tetrahedral truss at three points.

*This work was done by Houfei Fang and Eastwood Im of Caltech, John Lin of ILC Dover LP, and Jim Moore of NeXolve Corporation for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48317*

## High-Speed Transport of Fluid Drops and Solid Particles via Surface Acoustic Waves

**The innovation can act as a bladeless wiper for raindrops.**

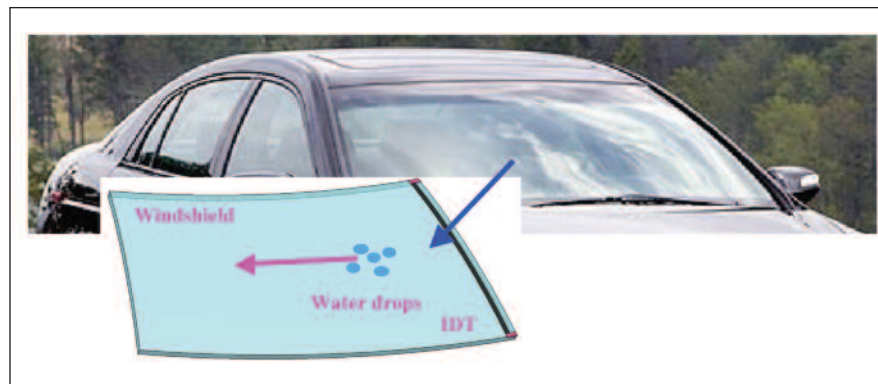
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A compact sampling tool mechanism that can operate at various temperatures, and transport and sieve particle sizes of powdered cuttings and soil grains with no moving parts, has been created using traveling surface acoustic waves (SAWs) that are emitted by an inter-digital transducer (IDT). The generated waves are driven at about 10 MHz, and it causes powder to move towards the IDT at high speed with different speeds for different sizes of particles, which enables these particles to be sieved.

This design is based on the use of SAWs and their propelling effect on powder particles and fluids along the path of the waves. Generally, SAWs are elastic waves propagating in a shallow layer of about one wavelength beneath the surface of a solid substrate. To generate SAWs, a piezoelectric plate is used

that is made of  $\text{LiNbO}_3$  crystal cut along the  $x$ -axis with rotation of  $127.8^\circ$  along the  $y$ -axis. On this plate are printed pairs of fingerlike electrodes in the form of a grating that are activated by subjecting

the gap between the electrodes to electric field. This configuration of a surface wave transmitter is called IDT. The IDT that was used consists of 20 pairs of fingers with 0.4-mm spacing, a total length



An automobile windshield with an Inter-Digital Transducer is shown as a replacement for movable wiper blades.